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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE WOLF SCHOOL QUADRANGLE, BIG HORN AND TREASURE COUNTIES, MONTANA

[Report includes 17 plates]

By

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ILLUSTRATIONS

[Plates are in pocket]

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Conversion table

To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.907	metric tons (t)
short tons/acre-ft	7.36	metric tons/hectare-meter (t/ha-m)
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)

INTRODUCTION

Purpose

This text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Wolf School quadrangle, Big Horn and Treasure Counties, Montana, (17 plates; U.S. Geological Survey Open-File Report 79-020). This set of maps was compiled to support the land planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1976, and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. Coal beds considered in the resource inventory are only those beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden.

Location

The Wolf School 7 1/2-minute quadrangle is in northeastern Big Horn and southern Treasure Counties, Montana, about 30 miles (48 km) south of Hysham, Montana, a town in the Yellowstone River valley about 71 miles (114 km) west-southwest of Miles City and 78 miles (125 km) east of Billings. U.S. Interstate Highway 94 and the main east-west route of the Burlington Northern Railroad follow the Yellowstone River and pass through Hysham.

Accessibility

The Wolf School quadrangle is accessible from the north by the Sarpy Road, an improved, graveled road which enters the northwest corner of the quadrangle 30 miles (48 km) south of U.S. Interstate Highway 94. The U.S. Interstate Highway 94 intersection with Sarpy Road is about 4 miles (6 km) east of Hysham. Additional roads, most of them unimproved, connect other parts of the quadrangle with the Sarpy Road. The quadrangle is also accessible from Hardin, Montana, a small town about 50 miles (80 km) east of Billings, Montana, on U.S. Interstate Highway 90. This access route, an improved, graveled road, exits U.S. Interstate Highway 90 at the Sarpy Road intersection 2 miles (3.2 km) east of Hardin; thence it goes east-northeast about 25 miles (40 km) to the west border of the Wolf School quadrangle.

A railroad spur runs southward from the main east-west line of the Burlington Northern Railroad near Hysham, parallel with the Sarpy Road, about 35 miles (56 km) to the Absaloka coal mine located near the center of the Wolf School quadrangle.

Physiography

The Wolf School quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. Most of the quadrangle has been dissected by Sarpy Creek and its tributaries (East and Middle Forks) which flow northwestward across the quadrangle.

The highest elevations in the quadrangle are near the southeast corner, at the west extremity of the Little Wolf Mountains. Elevations of the high ridges reach 4,120 feet (1,256 m). The lowest elevation, just under 3,180 feet (969 m), is on Sarpy Creek near the northwest corner of the quadrangle. The topographic relief is 940 feet (287 m).

Climate

The climate of Big Horn and Treasure Counties is characterized by pronounced variations in seasonal precipitation and temperature. Annual precipitation in the region varies from less than 12 inches (30 cm) to 16 inches (41 cm). The heaviest precipitation is from April to August. The largest average monthly precipitation is during June. Temperatures in eastern Montana range from as low as -50°F (-46°C) to as high as 110°F (43°C). The highest temperatures occur in July and the lowest in January; the mean annual temperature is about 45°F (7°C) (Matson and Blumer, 1973, p. 6).

Land status

The Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA) boundary has been drawn around the areas of higher elevation in the east half of the Wolf School quadrangle, as shown by the Coal Data Map (pl. 2). This map also shows the land ownership status. There were no outstanding Federal coal leases or prospecting permits of record as of 1977.

The map shows the present location of the Crow Indian Reservation boundary as well as the position of the old boundary established in 1868. The old boundary is located about 0.5 mile (0.8 km) west of the east boundary of the quadrangle. The U.S. Government obtained the lands west of the old boundary and north of the present Reservation boundary from the Crow Indians by cession in 1904, examined the lands for coal, and disposed of certain lands while retaining the coal rights. In 1958 the U.S. Government returned to the Crow Indians the remainder of the Federal coal lands west of the old boundary line. Specific coal bed maps and coal resource determinations in this report are limited to the area east of the old boundary.

GENERAL GEOLOGY

Previous work

Rogers and Lee (1923) mapped the north seven-eighths of the Wolf School quadrangle (the part north of the Crow Indian Reservation boundary) as part of the Tullock Creek coal field, Rosebud and Big Horn Counties, Montana. Thom and others (1935) mapped the south one-eighth of the quadrangle as part of the geology of Big Horn County and the Crow Indian Reservation, Montana. Tudor (1975) mapped most of the quadrangle as part of the geologic exploration and development of coal in the Sarpy Creek Area, Big Horn County, Montana, while an employee of Westmoreland Resources.

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The bedrock units belong to the Fort Union Formation (Paleocene) which is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Rogers and Lee (1923, p. 29) represented the Tullock to be a member of the Lance Formation (Tertiary?), but since 1949 the U.S. Geological Survey has considered the Tullock to be the lowermost member of the Fort Union Formation in Montana. The Tullock Member does not crop out in the Wolf School quadrangle; the lowest outcropping beds are in the Lebo Shale Member.

The Lebo Shale Member crops out in the stream bottoms of Sarpy Creek and its tributaries in the western and northern parts of the quadrangle. The member is 135 to 155 feet (41 to 47 m) thick and consists of soft, dark-gray to olive-gray and drab shale with a few beds of gray or yellow sandstone (Rogers and Lee, 1923, p. 35). The strata weather into treeless slopes and badlands. The Lebo Shale Member may carry two thin coal beds, lying about 20 and 70 feet (6 and 21 m) below the top of the member. However, only rarely are these found to contain as much as 1.5 feet (0.46 m) of even moderately clean coal (Rogers and Lee, 1923, p. 39).

The Tongue River Member forms the exposed bedrock unit throughout the higher elevations of the central and eastern areas of the quadrangle. The member consists of light-colored sandstone, sandy shale, and several important coal beds. The thicker coal beds have burned along the outcrops, and this has fused the overlying rock into reddish-colored clinker. The Tongue River Member is at least 1,275 feet (389 m) thick in the Little Wolf Mountains, several miles to the east (Rogers and Lee, 1923, p. 41); however, in the Wolf School quadrangle some of the member has been removed by erosion so that only about 970 feet (296 m) remains.

Coal and other rocks comprising the Tongue River Member were deposited in a continental environment at elevations of perhaps a few tens of feet (a few meters) above sea level in a vast area of shifting flood plains, sloughs, swamps, and lakes that occupied the Northern Great Plains in Paleocene (early Tertiary) time.

Representative samples of the sedimentary rocks overlying and interbedded with minable coal beds in the eastern and northern Powder River Basin have been analyzed for their trace element content by the U.S. Geological Survey and the results summarized by the U.S. Department of Agriculture and others (1974) and by Swanson (in Mapel and others, 1977, pt. A, p. 42-44). The rocks contain no greater amounts of trace elements of environmental concern than do similar rock types found throughout other parts of the western United States.

Structure

The Wolf School quadrangle is in the northwestern part of the Powder River structural basin. The strata in general dip southeastward at about 60 feet per mile (11.4 m per km) or less. In places the regional structure is modified by low-relief folds (Rogers and Lee, 1923, pl. 10).

COAL GEOLOGY

Six coal beds, all in the Tongue River Member, are mapped on the surface in this quadrangle (pl. 1) or are shown in section on plate 3. Only four of these are of sufficient thickness to contain economic reserves. The stratigraphically lowest of these four is the Robinson coal bed, which is about 200 feet (61.0 m) above the base of the Tongue River Member. The Robinson coal bed is overlain by a noncoal interval of about 30 feet (9 m), the Stocker Creek coal bed, a noncoal interval of 60 feet (18 m), the Rosebud-McKay coal bed, a noncoal interval of 3 feet to 30 feet (0.9 to 9.1 m), and the Q coal bed. Two local coal beds, lying 240 and 370 feet (73 and 113 m) above the Q coal bed, respectively, are too thin to contain economic resources.

The trace element content of coals in the quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Robinson coal bed

The Robinson coal bed was first described by Dobbin (1930, p. 27) from outcrops on the Robinson Ranch in the McClure Creek quadrangle situated just northeast of the Wolf School quadrangle. The Robinson coal bed crops out on the valley slopes of Sarpy Creek, East Fork Sarpy Creek, and their tributaries. Much coal has been burned along the outcrops resulting in broad areas of clinker. In the southwest quarter of the quadrangle, the Robinson coal burn has extended upward to include the overlying coal beds, producing thick clinker masses (pl. 1).

The detail maps (structure, isopach, etc.) of the Robinson coal bed are limited to the area containing Federal coal, a narrow strip along the east boundary of the quadrangle. Within this area the Robinson coal bed dips gently southeastward, about 40 feet per mile (7.6 m per km), and decreases from over 18 feet to about 12 feet (5.5 m to 3.7 m) in thickness (pl. 11). The overburden on the Robinson coal bed ranges from zero to over 800 feet (244 m) in thickness (pl. 12). This overburden includes the Stocker Creek, Rosebud, and Q coal beds, or their clinker where they have burned.

There are no known published chemical analyses of the Robinson coal. However, a sample of the overlying Rosebud coal has been analyzed from a core in the McClure Creek quadrangle just northeast of the Wolf School quadrangle. It is assumed that the Robinson coal is similar in rank in the Rosebud coal in that quadrangle and is subbituminous B.

Stocker Creek coal bed

The Stocker Creek coal bed was first described by Dobbin (1930, p. 27) from outcrops near the head of Stocker Creek (in the Colstrip West and Trail Creek quadrangles) in the Forsyth coal field, about 12 miles (19 km) northeast of the Wolf School quadrangle. The Stocker Creek coal bed crops out on the valley slopes just above the Robinson coal bed, but is often obscured by clinker beds formed by the burning of the underlying Robinson and overlying Rosebud-McKay coal beds (pl. 1). Structure contours on top of the Stocker Creek coal bed conform to structure on the other coal beds in the quadrangle, dipping gently southeastward. The thickness decreases southward from 6 feet to less than 3 feet (1.8 m to less than 0.9 m), as shown on plate 14. Overburden on the Stocker Creek coal bed ranges from zero to more than 500 feet (152 m) in thickness (pl. 15). This overburden includes the Rosebud and Q coal beds or their clinker where burned.

There are no known published chemical analyses of the Stocker Creek coal. However, the overlying Rosebud coal bed has been analyzed from a core sample in the McClure Creek quadrangle just northeast of the Wolf School quadrangle. It is assumed that the Stocker Creek coal is similar in rank to the Rosebud coal in that quadrangle and is subbituminous B.

Rosebud-McKay coal bed

The Rosebud coal bed was first described by Dobbin (1930, p. 27) from outcrops along Rosebud Creek in the Forsyth coal field. A specific type locality was not given. The McKay coal bed was also described by Dobbin without designating a type locality. The McKay bed may be considered a split of the Rosebud (Dobbin, 1930, p. 27).

The Rosebud-McKay coal bed crops out on the upper slopes of Sarpy Creek, East Fork Sarpy Creek, and their tributaries. Considerable coal has been burned along the outcrops, leaving large areas of clinker. In the southwest quarter of the Wolf School quadrangle, the Rosebud-McKay clinker has merged with the underlying Robinson and the overlying Q coal bed clinkers (pl. 1).

Except where interrupted by gentle folding, the Rosebud-McKay coal bed dips eastward about 40 feet per mile (7.6 m per km) as shown on plate 8, and except for minor variations decreases in thickness southward from more than 24 feet (7.3 m) to less than 5 feet (1.5 m), as shown on plate 7. The overburden above the Rosebud-McKay coal bed ranges from zero to more than 500 feet (152 m) in thickness (pl. 9). This overburden includes the Q coal bed or its clinker where it has been burned.

There are no known published chemical analyses of the Rosebud-McKay coal (separate from the Robinson coal) in the Wolf School quadrangle. However, a chemical analysis of Rosebud coal from drill hole RB-66 in sec. 13, T. 2 N., R. 38 E. in the McClure Creek quadrangle about 5 miles (8 km) northeast of the Wolf School quadrangle shows ash 11.17 percent, sulfur

0.68 percent, and heating value 8,820 Btu per pound (20,515 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 79). This heating value converts to about 9,900 Btu per pound (23,027 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal is subbituminous B in rank. A chemical analysis of coal mined from both the Rosebud and Robinson coal beds at the Absaloka coal mine in the Wolf School quadrangle indicates a rank high in the subbituminous C classification (see page 12 for details).

Q coal bed

The Q coal bed was described by Rogers and Lee (1923, p. 75) from outcrops in the southeast part of the Tullock coal field (in this, the Wolf School quadrangle), Rosebud and Big Horn Counties, Montana.

The Q coal bed is separated from the Rosebud coal bed below it by a noncoal interval ranging in thickness from 3 to 30 feet (0.9 to 9.1 m), and may actually be a split of the Rosebud bed. If so, it is probably the stratigraphic equivalent of the Lee coal bed as mapped in quadrangles to the north and east of the Wolf School quadrangle.

The Q coal bed crops out around the higher elevations in the east half of the Wolf School quadrangle. A gentle dip eastward conforms to the structure of the coal beds below. The thickness of the Q coal bed is consistently less than 5 feet (1.5 m) except in the northeast corner of the quadrangle where it increases to more than 6 feet (1.8 m), plate 4. The overburden on the Q bed ranges from zero to over 400 feet (122 m) in thickness (pl. 5).

There are no known published chemical analyses of the Q coal. It is assumed that the Q coal is similar in rank to the Rosebud coal in this area and is subbituminous B.

COAL MINES

The Absaloka coal mine (formerly the Sarpy Creek Mine) is a large surface mine located near the center of the Wolf School quadrangle about 2.5 miles (4 km) north of the Crow Indian Reservation. The mine is located on land which was formerly part of the Indian Reservation as established in 1868, but was ceded to the U.S. Government in 1904. The government retained the coal rights until 1958, when they were returned to the Crow Indian Tribe.

The Absaloka Mine is operated by Westmoreland Resources, a partnership of Westmoreland Coal Company, Penn Virginia Corporation, Kewanee Oil Company, and Morrison-Knudsen Company, Inc. (Rose, 1975, p. 165). The mine was opened in 1973, and the first coal was shipped in 1974.

The Rosebud-McKay and Robinson coal beds are mined by stripping the overburden by dragline and removing the coal with a front-end loader, the Rosebud-McKay coal bed first, and then the Robinson.

The Robinson coal bed ranges from 14 to 23 feet (4.3 to 7 m) in thickness and lies about 200 feet (61.0 m) above the base of the Tongue River Member. The Rosebud-McKay coal bed is 25 to 35 feet (7.6 to 10.7 m) thick and lies 50 to 120 feet (15.2 to 36.6 m) above the Robinson coal bed (Tudor, 1975, p. 159).

Coal production from the mine during 1977 was 4,529,000 short tons (4,108,700 t) of which 60 percent was from the Rosebud-McKay bed, and 40 percent was from the Robinson bed (McGraw-Hill, 1978, p. 967). The produced coal was reported to analyze ash 10 percent, sulfur 0.75 percent, and Btu 8,450 per pound (19,655 kJ/kg) on an as-received basis (McGraw-Hill, 1978, p. 967). This heating value converts to about 9,400 Btu per pound (21,864 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal, in the proportions used from both the Rosebud-McKay and Robinson coal beds, is subbituminous C in rank.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle.

Coal resource tonnages shown in this report are the Reserve Base (RB) part of the Identified Resources and the Hypothetical (HYP) part of the Undiscovered Resources, as discussed in U.S. Geological Survey Bulletin 1450-B (1976).

The Reserve Base for subbituminous coal is coal that is 5 feet (1.5 m) or more thick, under 3,000 feet (914 m) or less of overburden, and located within 3 miles (4.8 km) of a point of coal bed measurement. Reserve Base is further subdivided into reliability categories according to their nearness to a measurement of the coal bed. Measured coal is coal within 0.25 mile (0.4 km) of a measurement, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Hypothetical coal resources are undiscovered resources in known mining districts (at least 3 miles or 4.8 km from a measurement point) that may reasonably be expected to exist based on known geologic conditions.

Reserves are the recoverable part of the Reserve Base coal. For surface-minable coal in this quadrangle, the coal reserves are considered to be 85 percent (the recovery factor for this area) of that part of the Reserve Base that is beneath 500 feet (152 m) or less of overburden, the stripping limit for multiple, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Estimated coal resources in the Wolf School quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 7, 11, and 14). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot (13,028 metric tons/hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve tonnage values for the Q, Rosebud-McKay, Robinson, and Stocker Creek coal beds are shown on plates 6, 10, 13, and 16, respectively, and are rounded to the nearest one-hundredth of a million short tons.

The total surface-minable and underground-minable Reserve Base tonnage of federally owned coal in the Wolf School quadrangle are calculated to be 81.49 million short tons (73.93 million t). There is, in addition, a total of 0.13 million short tons (0.12 million t) of Hypothetical (HYP) coal. The Reserve Base and Hypothetical tonnage totals per section are shown in the northwest corner of each section on CRO plate 2 and by development-potential category in tables 1 and 2. All numbers are rounded to the nearest one-hundredth of a million short tons. About 2 percent of the Reserve Base tonnage is classed as Measured, 25 percent as Indicated, and 73 percent as Inferred.

COAL DEVELOPMENT POTENTIAL

Areas where coal beds are 5 feet (1.5 m) or more thick and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and were assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining-ratio values for subbituminous coal is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor = 0.85
0.911 = conversion factor (cu. yds./ton)

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO maps, plates 5, 9, 12, and 15 for the Q, Rosebud-McKay, Robinson, and Stocker Creek coal beds, respectively. These mining-ratio values for each development-potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey. Estimated tonnages in each development-potential category (high, moderate, and low) for surface mining are shown in table 1.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). If such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes, etc.

The coal development potential for surface-mining methods (less than 500 feet or 152 m of overburden) is shown on the CDP map (pl. 17). Most of the 40-acre (16.2-ha) tracts are rated as having a high development potential, although some of the coal in these high-rated tracts may fall into the moderate or low development-potential categories in table 1. All the Federal coal lands in the quadrangle are in a strip about 0.75 mile (1.2 km) wide along the east border of the quadrangle. Most of these Federal coal lands have a high development potential, as shown on plate 17. The high rating results from two superimposed coal beds, the Robinson, and the overlying Rosebud-McKay. Because of favorable thickness (pl. 11) and relatively thin overburden, the Robinson coal bed has a high development potential (mining-ratio values 0 to 10) in the east-central part of the quadrangle (pl. 12). North and south of this area of high development potential are thin bands in which the Robinson coal bed has a moderate development potential (mining-ratio values 10 to 15). Near the southeast and northeast corners of the quadrangle, where the overburden is thicker, the mining-ratio values are greater than 15 and the Robinson coal has a low development potential. This overburden includes the Rosebud-McKay coal bed, which is about 90 feet (27 m) above the Robinson coal bed. Because the Rosebud-McKay coal bed is moderately thick (pl. 7), and its overburden is not excessive, most of the Rosebud-McKay coal in the east-central part of the quadrangle has a high development potential (pl. 9). Only near the southeast and northeast corners of the quadrangle are there small areas of moderate and low development potential.

The Q and Stocker Creek coal beds contain coal resources near the northeast corner of the quadrangle, but the mining-ratio values are high, and the development potential is low (pls. 5 and 15).

About 78 percent of the Federal coal land in this quadrangle has high development potential, 1 percent has moderate development potential, 12 percent has low development potential, and 9 percent has no development potential (pl. 17).

Development potential for underground mining and in-situ gasification

Coal resources recoverable by underground mining methods in the Wolf School quadrangle are estimated to be 6.69 million short tons (6.07 million t), as shown in table 2. These resources lie at depths below 500 feet (152 m) but less than 800 feet (244 m). For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin area. The coal development potential for underground-mining methods is therefore rated as low, and a Coal Development Potential map was not made for the quadrangle.

In-situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in-situ gasification of coal found below the stripping limit in this area is rated as low.

Table 1.--Surface-minable coal resource tonnage by development-potential category for Federal coal land (in short tons) in the Wolf School quadrangle, Big Horn and Treasure Counties, Montana

[Development potentials are based on mining ratios (cubic yards of overburden/short ton of recoverable coal). To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Reserve Base tonnage				
Q	0	0	120,000	120,000
Rosebud-McKay	14,660,000	8,730,000	11,030,000	34,420,000
Stocker Creek	0	0	3,140,000	3,140,000
Robinson	17,690,000	7,170,000	12,260,000	37,120,000
Total	32,350,000	15,900,000	26,550,000	74,800,000
Hypothetical Resource tonnage				
Stocker Creek	0	0	130,000	130,000
Total	0	0	130,000	130,000
Grand Total	32,350,000	15,900,000	26,680,000	74,930,000

Table 2.--Underground-minable coal resource tonnage by development-potential category for Federal coal land (in short tons) in the Wolf School quadrangle, Big Horn and Treasure Counties, Montana

[To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential	Moderate development potential	Low development potential	Total
Robinson	0	0	6,690,000	6,690,000
Total	0	0	6,690,000	6,690,000

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